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FORMATION ENVIRONMENTAL

MEMORANDUM

TO: Art Burbank – U.S. Forest Service

FROM: Fred Charles, Andy Koulermos

DATE: September 8, 2017

SUBJECT: Evaluation of copper concentrations reported for small mammal tissue samples from the Smoky Canyon Mine

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In 2010, Formation Environmental collected small mammals at the Smoky Canyon Mine for chemical analyses to support the site-specific ecological risk assessment (SSERA). The tissue samples were submitted to Columbia Analytical Services (Kelso, WA), now ALS Environmental, for analysis of the chemicals of potential concern listed in the 2010 Final Smoky Canyon Mine RI/FS Sampling and Analysis Plan (SAP). A number of the analysis results for copper were identified in the SSERA as having concentrations of copper that appeared to be anomalously high. This observation was based on comparisons to the copper concentrations in soil and other tissue samples collected from the same areas, to concentrations[1] measured in small mammals collected from other Southeast Idaho phosphate mine sites, and to concentrations reported in the literature for copper-contaminated sites.

Because copper was not detected in any other environmental media at Smoky Canyon Mine at concentrations that would be considered to be elevated, the cause of the apparently anomalously high copper concentrations in the small mammal tissue samples was unclear. In order to attempt to assess the veracity of the data, additional small mammal tissue samples were collected in 2016 at a subset of the 2010 locations for further evaluation of copper concentrations.

This memorandum briefly describes the small mammal sampling and analysis activities at the Smoky Canyon Mine, provides an evaluation of the data, summarizes a literature review of copper concentrations measured in small mammal tissue at a variety of copper-contaminated sites, and summarizes the information that was compiled to evaluate the sampling and analysis methods associated with the anomalously high

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[1] Average 9.2 mg/kg (whole body, dry-weight basis) and maximum 36.4 mg/kg in whole deer mice specimens.

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copper results and the accuracy of those results. This memo also describes how several possible causes of error that could be associated with the anomalous copper results were evaluated. Information was compiled to evaluate whether issues with sampling methods or laboratory analyses contributed to the elevated copper concentrations reported for individual samples. Results of statistical analyses for outliers are also presented. Together, the compiled and summarized information shows that copper is not a Site-related contaminant and that anomalously high copper results for small mammals may have been a result of laboratory errors in 2010 and 2016, or from euthanizing equipment used in 2010.

LABORATORY METHODS

Small mammals were trapped and collected for laboratory analyses on two separate occasions at the Smoky Canyon Mine:

- 108 small mammal specimens were collected in 2010 at 55 locations.
- 47 specimens were collected in 2016 at a subset of the 2010 locations (11 locations).

For each specimen, whole-body tissue was first homogenized and then freeze dried prior to analysis for metals, including copper. The samples collected in 2010 were analyzed for copper by ICP-AES (EPA Method 6010B); the Smoky Canyon Mine RI/FS QAPP (part of the SAP) specified that ICP-MS be used for analysis of copper in small mammal tissue. In 2016, ICP-MS (EPA Method 6020A) was used for the copper analyses. All concentrations were reported in mg/kg on a dry-weight basis. Copper results for the small mammal tissue samples are provided in Table 1.

The quality of the laboratory data was assessed in accordance with the data quality indicators specified in the Final Smoky Canyon Mine RI/FS SAP, as well as the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, to the extent possible. Copper results associated with one of the six sample delivery groups (SDGs), K1007628, were qualified as estimated with possible high bias (J+) due to elevated recovery of copper in the matrix spike sample. The lab had also assigned a flag of "N" to copper results in this SDG, indicating matrix spike percent recovery was outside control limits. None of the other copper results from 2010 were assigned validation qualifiers (see Table 1), and no validation qualifiers were assigned to the copper results associated with 2016 samples.

After review of the results, 9 of the 47 samples collected in 2016 were selected for inter-laboratory re-analysis by ACZ Laboratories (Steamboat Springs, CO). ACZ analyzed the samples for copper using ICP-MS (EPA Method 6020A).

SMOKY CANYON MINE DATA EVALUATION

The 2010 sampling effort included collection of small mammal and soil samples. The spatial distribution of copper results at the 55 locations of co-located soil and small mammal sampling is shown in Figure 1. There is no apparent spatial pattern for the small mammal data. The copper results in these samples are shown in Table 2. The maximum copper concentration measured in soil at the Site was 120 mg/kg, roughly an order of magnitude lower than EPA's Ecological Soil Screening Level for mammalian herbivores of 1,100 mg/kg (Ecological Soil Screening Levels for Copper, Interim Final, OSWER Directive 9285.7-68, EPA 2007). These data are also plotted in Figure 2, which shows that copper concentrations in small mammals are not correlated with concentrations in soil (R-squared value is 0.029); similarly, copper concentrations are not correlated for small mammals and co-located vegetation sampled in 2010 (R-squared value is 0.055). Further, copper concentrations for soils and co-located vegetation are not correlated (R-squared value is 0.071). These analyses indicate that the copper results for small mammals are not Site-related.

The 2016 sampling effort entailed collection of small mammal samples at a subset (11) of the 2010 locations. Overall, the copper results for the 2016 small mammal samples were much lower than the results for the 2010 samples, although still higher than expected concentrations for small mammal tissue. The spatial distribution of copper results for the 2016 samples is shown in Figure 3. The relationship between copper concentrations in soil (2010 data) and small mammal (2016 data) is shown in Figure 4. The conditions on the Pole Canyon ODA have changed since 2010 (a cover was installed in 2015) and, therefore, these data were excluded from the analysis. As shown, copper concentrations in small mammals (2016 data) are also not correlated with concentrations in soil (R-squared value is 0.003). This is a further indication that the copper results for small mammals in 2016 are not Site-related.

As noted above, inter-laboratory re-analysis by ACZ was also conducted for comparison with results from analysis by ACZ. The copper results for the 9 samples from 2016 that were analyzed by both ALS and ACZ are presented in Table 3 and Figure 5. As shown, the results are highly correlated (R-squared value is 0.97), with the ACZ results at approximately 30% of the ALS values. However, the ACZ results are still higher than expected concentrations for small mammal tissue.

LITERATURE REVIEW

In order to assess the 2010 and 2016 data from the Smoky Canyon Mine versus what has been observed elsewhere, a literature review was performed to gather information on copper concentrations measured in small mammal tissue at a variety of copper-contaminated sites (e.g., mine sites with waste rock and tailings, refineries, sediment contaminated sites, and agricultural areas). Published copper concentrations for small mammal tissue[2] and other environmental media (sediment, soil, water, vegetation tissue, insect tissue) were reviewed (Table 4), including data collected from other Southeast Idaho phosphate mine sites (e.g., MWH [2001] in Table 4).

The literature review indicated that copper concentrations in small mammal tissue are typically less than 100 mg/kg (dry-weight basis). Higher concentrations of copper have been observed in organs, particularly kidney and liver versus whole body analyses. The maximum copper concentration found in the literature was 622 mg/kg (dry-weight basis, organ tissue [liver]) (Stelter 1980), whereas the highest copper concentrations reported for the whole body samples collected at the Smoky Canyon Mine were an order of magnitude higher. None of the reviewed publications contained documented occurrences of copper concentrations approaching the anomalous tissue concentrations at Smoky, even in tissue samples collected from areas with extremely high copper concentrations in environmental media (e.g., at copper refineries and tailings disposal areas related to copper mines).

REVIEW OF FIELD METHODS AND EQUIPMENT

Traps and other equipment used for collection of small mammals were evaluated as potential sources of copper contamination. Galvanized steel live traps were used for sample collection in 2010, and plastic snap traps were used in 2016. Small mammals that were live trapped (in 2010 only) were later euthanized by asphyxiation using compressed carbon dioxide (CO_2) gas in metal cartridges outfitted with brass valves.

The metal cartridges and brass valves were identified as a potential source of copper to the small mammal carcasses. Therefore, seven cartridges and valves similar to those used for euthanization in 2010 were analyzed as a potential cause of the high copper results observed in some of the 2010 samples. Lab method ICP-MS was used for analysis of copper in acid-leachates of cartridges, seals, and valves and the CO_2–cartridge contents. For cartridge material, seven empty CO_2 cartridges were totally

[2] Reported copper concentrations in tissue of various organs, stomach contents, and total body specimens were compiled.

submerged in nitric acid[3] and then the fluid on the inside of each cartridge was analyzed for copper. For seals, the top seal for each of the seven cartridges was removed, submerged in nitric acid, and then the acid solution was analyzed for copper. For the valves, three used and three new (i.e., previously unused) valves were totally submerged in nitric acid and then the fluid on the inside of each valve was analyzed for copper. Finally, the compressed CO_2 gas within each of the seven cartridges was extracted with a valve attached with tubing into 100 mL of deionized water and then the valve was acid leached followed by analysis of the acid leachate for copper.

The cartridge materials leached contained 1.25 to 11.7 mg/kg copper while the seals (0.59 to 1.43 mg/kg) and CO_2 (0.11 to 0.13 mg/L) only yielded trace amounts of copper. The new (unused) valves contained 8,800 to 10,100 mg/kg of copper. The used valves contained 12,400 to 14,700 mg/kg of copper. If brass shavings (due to wear and tear of the valve assembly) were to get incorporated with the euthanized animal (e.g., entangled in the fur), high copper results would be possible, depending on the size of the brass particles relative to the aliquot selected for analysis.

Because of the high copper concentrations found in the type of brass valves used for sampling in 2010, plastic snap traps were used instead during sampling in 2016. This equipment change eliminated all potential sources of copper contamination in the sample collection process. Regardless, concentrations in several 2016 tissue samples were, while much lower than observed in 2010, still higher than all whole body tissue data identified in the literature search. This indicates that while contamination from the sampling methods could have had an impact in the 2010 data, sample contamination was not likely to be the only source of copper in the tissue samples.

Review of Site Conditions

Other potential sources of copper in small mammal tissue samples were identified based on Site conditions at the time of the 2010 and 2016 sampling events. Copper contamination is not associated with phosphate mining and, as discussed above, was not identified in the RI at elevated concentrations in soils. Therefore, materials used for revegetation and other mine activities were identified and evaluated.

Revegetation includes application of seed and fertilizer/amendments. The source of seed was checked to see if a copper-containing substance, such as a fungicide, was included in the seed mixture; no such substance was added to the seed. As well, copper was not identified in any mulches (including coloration), tackifiers, or

[3] 1:4 mixed solution of HNO3 (nitric acid):H2O.

fertilizers/amendments used for reclamation at the mine. Electrical wiring associated with the mine's MineStar communication system was the only other potential source identified. This wiring could be accessed by small mammals, as evidenced by rodent chew marks in wires in some areas including near the locations of the 3 highest copper results (2 samples at DPL-18 and 1 sample at DPL-21) from re-sampling in 2016. While this could be a potential source of copper for small mammals in the highest 2016 samples, the wiring was accessible only in localized areas and at only several places throughout the mine which does not explain the elevated copper results in 2010.

REVIEW OF SAMPLE PREPARATION AND ANALYSIS METHODS

Although the laboratory reports (chain of custody forms, results, run logs, preparation logs, and raw data) were previously validated, those reports were reviewed again to identify any procedural or reporting errors associated with the copper results in question that would not have been checked during the data validation process.

Preparation logs were reviewed to evaluate sample mass and volumetric information for sample digestion, as well as resultant concentration calculations. This information indicated that the concentrations reported were consistent with raw ICP output (following corrections for the recorded digestion and dilution volumes). Sample processing notes included in the laboratory reports did not, however, include the information needed to confirm that the recorded dilution factors used to prepare each sample for analysis by ICP-MS (i.e., the dilution volume used for each sample) were correct. ALS was contacted to request additional sample processing records for this purpose. ALS indicated that the dilution factors reported with each sample were manually recorded by the lab technicians, but no additional record of the dilution volume used for each sample was available from ALS. Therefore, the dilution factors reported for each sample could not be confirmed as correct/accurate.

The dilution factor is used to calculate the final concentration from the ICP raw data, and an error made recording the dilution factor will lead to an incorrect concentration. The ALS reports do not provide sufficient detail to allow for identification of any errors in entries for dilution factors. For this reason, unconfirmed dilution factors remain a possible source of error for the reported copper concentrations.

Results of the inter-laboratory comparison, noted above, showed that copper results from ACZ were highly correlated with those from ALS but were approximately 30% of the ALS values. The sample preparation records provided by ACZ were also reviewed (from the re-analysis of selected 2016 samples), which included all of the sample mass and volumetric information needed to confirm the dilution factors reported by ACZ.

All of the dilution factors reported by ACZ could be confirmed as correct from data included in the preparation record.

Most of the samples collected in 2010 and analyzed by ALS had dilution factors of 1; three of the samples had dilution factors of 10 (refer to Table 1). The three samples with dilution factors of 10 also had copper results greater than 1,000 mg/kg, but other samples with similarly high copper results had dilution factors of 1. For the samples collected in 2016, all of the copper results reported by ALS had dilution factors of 5. The subset of the 2016 samples that was sent to ACZ for re-analysis were analyzed for copper at dilution factors ranging from 130 to 250. The dilution factors of samples re-analyzed by ACZ were higher than those reported by ALS, and corresponding copper concentrations reported by ACZ were lower.

These observations indicate possible errors in the dilution factors recorded by ALS. The dilution factors recorded and resultant copper concentrations reported by ACZ were confirmed as correct. However, the ALS data reports do not provide the dilution volume records needed to confirm the accuracy of the dilution factors used to calculate final copper concentrations. As such, the dilution factors reported by ALS, and related copper results, cannot be confirmed as correct.

STATISTICAL OUTLIER ANALYSIS

Figure 6 shows copper concentrations reported for the small mammals collected at Smoky in 2010 and 2016. For the 2010 data set, the highest values stand out as distinctly different from the other values. As well, the four highest 2016 results appear to be distinctly different from the other values in the 2016 data set. Therefore, a test for outliers was performed for each data set using EPA's ProUCL software and Rosner's test at the 99 percent confidence level ($\alpha = 0.01$). The seven highest values in the 2010 data set, greater than 1,100 mg/kg, were identified as statistical outliers, and the four highest values in the 2016 data set, greater than 100 mg/kg, were identified as statistical outliers. These outliers are inconsistent with the overall distribution of data for 2010 and 2016, as they were identified as statistical outliers at a high confidence level.

SUMMARY OF FINDINGS

The findings from the additional review of copper concentrations reported for small mammal samples collected at the Smoky Canyon Mine can be summarized as follows:

- The highest copper concentration measured in soils was 120 mg/kg, an order of magnitude lower than EPA's Ecological Soil Screening Level (1,100 mg/kg) for mammalian herbivores.
- There is no relationship between copper results for small mammals and for soil (and vegetation), which indicates that the results for small mammals are not Site-related.
- The copper concentrations of some of the Smoky Canyon Mine samples are suspect given their deviation from copper concentrations found in mammal tissues from a variety of copper-contaminated settings. A review of published scientific literature indicates that copper concentrations did not exceed 622 mg/kg in any sample, including those collected from copper-contaminated sites. This includes samples of whole body tissue, specific organs, and stomach contents. Analyses of small mammal, whole body, tissue samples collected at other locations associated with phosphate mines in southeast Idaho indicate copper concentrations less than 100 mg/kg, which is consistent with findings from the literature review.
- The small mammal samples from Smoky Canyon Mine were collected using trapping and euthanizing equipment that was later evaluated for its potential to contaminate the small mammal specimens with copper. Although the CO_2 gas cartridges and valves used in 2010 were found to contain concentrations of copper as high as 14,700 mg/kg, there was no consistent correlation between copper concentrations and the equipment type used to collect the small mammals and, therefore, no clear cause-and-effect relationship. However, these components cannot be ruled out as a possible source of copper contamination during euthanization for the 2010 samples.
- Other potential sources of copper in small mammal tissue samples at the Site during the 2010 and 2016 sampling events were evaluated. Materials utilized during revegetation activities, including seed and fertilizer/amendments were evaluated and copper was not identified. Also, electrical wires associated with the MineStar system, which can be accessed by small mammals, could be a source of copper as evidenced by rodent chew marks in wires in some areas including near the locations of the 3 highest copper results (2 samples at DPL-18 and 1 sample at DPL-21) from re-sampling in 2016. However, the wiring is accessible only in localized areas and at only several places throughout the mine, which does not explain the elevated results for copper in 2010.
- The 2010 tissue samples from Smoky Canyon Mine were analyzed for copper using an alternative ICP method - ICP-AES, EPA Method 6010 - that varied from the method specified in the RI/FS SAP. Samples collected in 2016 were analyzed for copper using ICP-MS, EPA Method 6020A, which was the method specified for analyses of tissue for

copper. Anomalously high copper concentrations were reported in samples analyzed by both of these methods and, therefore, use of the alternative ICP method does not appear related to the anomalous results.

- Although laboratory recording errors cannot be confirmed at this time, due to the lack of detailed sample preparation notes in the final reports prepared by ALS, the elevated copper concentrations of some of the Smoky Canyon Mine small mammal samples remain suspect and should be identified to data users as potentially inaccurate.
- Statistical outlier analysis of the 2010 and 2016 data sets shows that the seven highest values in the 2010 data set (greater than 1,100 mg/kg) and the four highest values in the 2016 data set (greater than 100 mg/kg) were identified as statistical outliers at a high confidence level.

CONCLUSION

Copper contamination is not associated with phosphate mining and copper was not identified in the Smoky Canyon Mine RI at elevated concentrations in soils. Further, the highest copper results from small mammal sampling in 2010 and 2016 are outliers at a high confidence level. Therefore, the elevated copper results for small mammal tissue samples collected at the Site are considered anomalous and will not be considered further in the CERCLA process.

TABLE 1
Listing of All Results and Dilution Factors, Including Data Validation Information

Mine site	Year	Sample ID	Cu result (mg/kg)	Validation qualifier	Dilution factor	Validation qualifier reason
Smoky	2010	SC0710-AP10-MT001	124	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP13-MT001	45.6	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP13-MT002	126	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP13-MT003	38.1	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP15-MT001	61.0	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP16-MT001	66.9	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP16-MT002	187	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP18-MT001	92.9	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP18-MT002	253	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP18-MT003	230	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP19-MT001	89.2	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP19-MT002	374	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP20-MT001	140	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP20-MT002	140	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP21-MT002	197	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP21-MT003	154	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP25-MT001	134	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP26-MT001	416	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP27-MT001	917	J+	1	Matrix spike % recovery > control limit
Smoky	2010	SC0710-AP29-MT001	11.9		1	
Smoky	2010	SC0710-DP16-MT001	23.4		1	
Smoky	2010	SC0710-DP16-MT002	18.8		1	
Smoky	2010	SC0710-DP26-MT001	25.7		1	
Smoky	2010	SC0710-DP27-MT001	23.4		1	
Smoky	2010	SC0710-DP27-MT002	14.5		1	
Smoky	2010	SC0710-DP29-MT001	20.9		1	
Smoky	2010	SC0710-DP29-MT002	20.9		1	
Smoky	2010	SC0710-LPPD-MT001	19.2		1	
Smoky	2010	SC0710-LSM-MT001	42.6		1	
Smoky	2010	SC0710-PCO05-MT001	17.1		1	
Smoky	2010	SC0710-PCO05-MT002	53.8		1	
Smoky	2010	SC0710-PCO06-MT001	17.1		1	
Smoky	2010	SC0710-PCO06-MT002	29.8		1	
Smoky	2010	SC0710-PCO07-MT001	55.7		1	
Smoky	2010	SC0710-PCO07-MT002	136		1	
Smoky	2010	SC0710-PCO10-MT001	51.8		1	
Smoky	2010	SC0710-PCO10-MT002	48.8		1	
Smoky	2010	SC0710-PCO12-MT001	47.4		1	
Smoky	2010	SC0710-PCO12-MT002	56.7		1	
Smoky	2010	SC0710-PCO12-MT003	1320		1	
Smoky	2010	SC0710-PCO14-MT001	2740		10	
Smoky	2010	SC0710-PCO14-MT002	1990		1	
Smoky	2010	SC0710-PCO14-MT003	3900		10	
Smoky	2010	SC0710-SV25-MT001	496		1	
Smoky	2010	SC0710-SV29-MT001	440		1	
Smoky	2010	SC0710-DP18-MT001	776		1	
Smoky	2010	SC0710-DP21-MT001	784		1	
Smoky	2010	SC0710-DP21-MT002	447		1	
Smoky	2010	SC0710-DP21-MT003	784		1	
Smoky	2010	SC0710-DP23-MT001	70.5		1	
Smoky	2010	SC0710-DP23-MT002	559		1	
Smoky	2010	SC0710-DP23-MT003	583		1	
Smoky	2010	SC0710-DP32-MT001	388		1	
Smoky	2010	SC0710-DP32-MT002	638		1	
Smoky	2010	SC0710-DP32-MT003	1030		1	
Smoky	2010	SC0710-DP33-MT001	2120		10	
Smoky	2010	SC0710-DP33-MT002	2110		1	
Smoky	2010	SC0710-DP33-MT003	773		1	
Smoky	2010	SC0710-DP34-MT001	383		1	
Smoky	2010	SC0710-DP34-MT002	90.4		1	
Smoky	2010	SC0710-DS7-MT001	155		1	
Smoky	2010	SC0710-DS7-MT002	685		1	
Smoky	2010	SC0710-DS7-MT003	539		1	
Smoky	2010	SC0710-SV23-MT001	213		1	
Smoky	2010	SC0710-SV23-MT002	387		1	

TABLE 1
Listing of All Results and Dilution Factors, Including Data Validation Information

Mine site	Year	Sample ID	Cu result (mg/kg)	Validation qualifier	Dilution factor	Validation qualifier reason
Smoky	2010	SC0710-SV27-MT001	565		1	
Smoky	2010	SC0710-SV28-MT001	180		1	
Smoky	2010	SC0710-DP25-MT001	329		1	
Smoky	2010	SC0710-DP25-MT002	160		1	
Smoky	2010	SC0710-DP25-MT003	140		1	
Smoky	2010	SC0710-EP11-MT001	816		1	
Smoky	2010	SC0710-EP11-MT002	619		1	
Smoky	2010	SC0710-EP11-MT003	182		1	
Smoky	2010	SC0710-EP12-MT001	231		1	
Smoky	2010	SC0710-EP12-MT002	369		1	
Smoky	2010	SC0710-EP12-MT003	278		1	
Smoky	2010	SC0710-EP14-MT001	141		1	
Smoky	2010	SC0710-EP14-MT002	50.1		1	
Smoky	2010	SC0710-EP15-MT001	161		1	
Smoky	2010	SC0710-EP18-MT001	90.4		1	
Smoky	2010	SC0710-EP19-MT001	153		1	
Smoky	2010	SC0710-EP19-MT002	114		1	
Smoky	2010	SC0710-EP21-MT001	73.4		1	
Smoky	2010	SC0710-EP22-MT001	361		1	
Smoky	2010	SC0710-EP22-MT002	121		1	
Smoky	2010	SC0710-EP22-MT003	80.5		1	
Smoky	2010	SC0710-EP25-MT001	944		1	
Smoky	2010	SC0710-EP25-MT002	520		1	
Smoky	2010	SC0710-EP25-MT003	210		1	
Smoky	2010	SC0710-EP26-MT001	330		1	
Smoky	2010	SC0710-EP26-MT002	148		1	
Smoky	2010	SC0710-EP26-MT003	273		1	
Smoky	2010	SC0710-EP27-MT001	138		1	
Smoky	2010	SC0710-EP27-MT002	176		1	
Smoky	2010	SC0710-EP28-MT001	134		1	
Smoky	2010	SC0710-EP28-MT002	129		1	
Smoky	2010	SC0710-EP28-MT003	306		1	
Smoky	2010	SC0710-ES3-MT001	137		1	
Smoky	2010	SC0710-ES3-MT002	66.0		1	
Smoky	2010	SC0710-ES4-MT001	405		1	
Smoky	2010	SC0710-ES4-MT002	217		1	
Smoky	2010	SC0710-HSCC1-MT001	268		1	
Smoky	2010	SC0710-LS-MT001	183		1	
Smoky	2010	SC0710-LS-MT002	280		1	
Smoky	2010	SC0710-LS-MT003	312		1	
Smoky	2010	SC0710-HS3-MT001	1500		1	
Smoky	2010	SC0710-LSS-MT001	886		1	
Smoky	2016	SC0716-APL27-MT001	24.2		5	
Smoky	2016	SC0716-APL27-MT002	54.8		5	
Smoky	2016	SC0716-DPL18-MT001	60.2		5	
Smoky	2016	SC0716-DPL18-MT002	242		5	
Smoky	2016	SC0716-DPL18-MT003	936		5	
Smoky	2016	SC0716-DPL21-MT001	43.9		5	
Smoky	2016	SC0716-DPL21-MT002	305		5	
Smoky	2016	SC0716-DPL21-MT003	90.0		5	
Smoky	2016	SC0716-DPL21-MT004	13.8		5	
Smoky	2016	SC0716-DPL21-MT005	14.0		5	
Smoky	2016	SC0716-DPL32-MT001	20.1		5	
Smoky	2016	SC0716-DPL32-MT002	17.5		5	
Smoky	2016	SC0716-DPL32-MT003	18.5		5	
Smoky	2016	SC0716-DPL32-MT004	50.6		5	
Smoky	2016	SC0716-DPL32-MT005	28.4		5	
Smoky	2016	SC0716-DPL33-MT001	11.9		5	
Smoky	2016	SC0716-DPL33-MT002	15.2		5	
Smoky	2016	SC0716-DPL33-MT003	17.3		5	
Smoky	2016	SC0716-DPL33-MT004	12.1		5	
Smoky	2016	SC0716-DPL33-MT005	29.3		5	
Smoky	2016	SC0716-EPL11-MT001	22.4		5	
Smoky	2016	SC0716-EPL11-MT002	56.6		5	
Smoky	2016	SC0716-EPL11-MT003	12.6		5	

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Mine site	Year	Sample ID	Cu result (mg/kg)	Validation qualifier	Dilution factor	Validation qualifier reason
Smoky	2016	SC0716-EPL11-MT004	16.8		5	
Smoky	2016	SC0716-EPL11-MT005	12.1		5	
Smoky	2016	SC0716-EPL25-MT001	12.1		5	
Smoky	2016	SC0716-EPL25-MT002	10.7		5	
Smoky	2016	SC0716-EPL25-MT003	13.2		5	
Smoky	2016	SC0716-EPL25-MT004	17.9		5	
Smoky	2016	SC0716-SV25-MT001	13.5		5	
Smoky	2016	SC0716-SV25-MT002	36.6		5	
Smoky	2016	SC0716-SV25-MT003	36.1		5	
Smoky	2016	SC0716-SV25-MT004	60.5		5	
Smoky	2016	SC0716-SV27-MT001	34.0		5	
Smoky	2016	SC0716-SV27-MT002	43.3		5	
Smoky	2016	SC0716-SV27-MT003	41.7		5	
Smoky	2016	SC0716-SV27-MT004	139		5	
Smoky	2016	SC0716-SV27-MT005	24.4		5	
Smoky	2016	SC0716-PCO12-MT001	56.4		5	
Smoky	2016	SC0716-PCO12-MT002	41.4		5	
Smoky	2016	SC0716-PCO12-MT003	30.0		5	
Smoky	2016	SC0716-PCO12-MT004	22.5		5	
Smoky	2016	SC0716-PCO12-MT005	19.0		5	
Smoky	2016	SC0716-PCO14-MT001	15.9		5	
Smoky	2016	SC0716-PCO14-MT002	15.0		5	
Smoky	2016	SC0716-PCO14-MT003	15.9		5	
Smoky	2016	SC0716-PCO14-MT004	11.5		5	

Notes:

mg/kg = Milligrams per kilogram (dry weight)

Validation qualifier J+ = The result is an estimated quantity, but the result may be biased high. (From EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, 2004)

Table 2
Copper Concentrations in Co-Located Soil and Small Mammal Samples (2010 Data)

Location	Soil Copper Concentration (mg/Kg)	Mammal Tissue Copper Concentration (mg/Kg)
APL-10	85.1	124
APL-13	60.5	45.6
		126
		38.1
APL-15	90.5	61
APL-16	31.3	66.9
		187
APL-18	120	92.9
		253
		230
APL-19	41.4	89.2
		374
APL-20	25.4	140
		140
APL-21	50	154
		134
		197
APL-25	16	134
APL-26	40.9	416
APL-27	43.3	917
APL-29	12.3	11.9
DPL-16	57.1	23.4
		18.8
DPL-18	48.5	776
DPL-21	64.1	784
		447
		784
DPL-23	42.9	583
		70.5
		559
DPL-25	61.1	329
		160
		140
DPL-26	33.2	25.7
DPL-27	48.3	23.4
		14.5
DPL-29	45.6	20.9
		20.9
DPL-32	109	1030
		388
		638
DPL-33	32.8	773
		2120
		2110
DPL-34	25.7	90.4
		383
DS-7	112	155
		685
		539
EPL-11	30.7	816
		619
		182
EPL-12	52.1	369
		278
		231

Table 2
Copper Concentrations in Co-Located Soil and Small Mammal Samples (2010 Data)

Location	Soil Copper Concentration (mg/Kg)	Mammal Tissue Copper Concentration (mg/Kg)
EPL-14	39.6	141
		50.1
EPL-15	53.7	161
EPL-18	12.1	90.4
EPL-19	11.4	153
		114
EPL-21	13.5	73.4
EPL-22	21.3	361
		121
		80.5
EPL-25	16.3	520
		210
		944
EPL-26	28.9	148
		273
		330
EPL-27	20.5	138
		176
EPL-28	26.6	134
		129
		306
ES-3	18.5	137
		66
ES-4	13.1	405
		217
HS-3	10.1	1500
HS-CC1	21.9	268
LP-PD	17	19.2
LS	14.7	183
		280
		312
LSm	22.2	42.6
LSS	32.2	886
PCO-05	41.1	17.1
		53.8
PCO-06	17.1	17.1
		29.8
PCO-07	42.2	136
		55.7
PCO-10	86.2	51.8
		48.8
PCO-12	84.5	47.4
		56.7
		1320
PCO-14	79.3	2740
		1990
		3900
SV-23	24.1	213
		387
SV-25	22.1	496
SV-27	35.2	565
SV-28	22.4	180
SV-29	29.9	440

TABLE 3
Comparison of Copper Results From Initial Analysis and Re-analysis by Second Laboratory

COCSampleID	Initial results (mg/kg)	Re-analysis results (mg/kg)	Re-analysis < initial result?	Relative % difference	Factor of difference
SC0716-DPL18-MT001	60.2	53.8	Yes	11	1.12
SC0716-DPL18-MT002	242	54.9	Yes	126	4.41
SC0716-DPL18-MT003	936	295	Yes	104	3.17
SC0716-DPL21-MT001	43.9	8.8	Yes	133	4.99
SC0716-DPL21-MT002	305	90.5	Yes	108	3.37
SC0716-DPL21-MT003	90	11.9	Yes	153	7.56
SC0716-SV27-MT004	139	30.7	Yes	128	4.53
SC0716-SV27-MT005	24.4	6.3	Yes	118	3.87
SC0716-PCO12-MT001	56.4	16.9	Yes	108	3.34
Mean	210.8	63.2		**Mean factor of difference**	4.04
Median	90	30.7			
Minimum	24.4	6.3			
Maximum	936	295			

Notes:
mg/kg = Milligrams per kilogram (dry weight)
Relative % difference = [(|Initial result - Reanalysis result|)/(Initial result + Reanalysis result)]*100
Factor of difference = Initial result/Reanalysis result

TABLE 4
Publications Reviewed and Reported Copper Concentrations in Mammal Tissue and Other Media

Title	Year	Authors	Journal	Description of Copper Concentrations in Mammal Tissue (dry weight basis)[1]	Copper Concentrations in Other Media
Heavy metal exposure, reproductive activity, and demographic patterns in white-footed mice (Peromyscus leucopus) inhabiting a contaminated floodplain wetland	2008	Levengood, J. M., and Heske, E. J.	Science of the Environment	White-footed mouse in area contaminated by smelting. Maximum (max) Cu = 31.1 mg/kg measured in organ (reported as 9.4 µg/g wet weight).	Soil (91 - 535 ppm)
Bioaccumulation of metals in plants, arthropods, and mice at a seasonal wetland	2001	Torres, K.C., and Johnson, M.	Environmental Toxicology and Chemistry	House mouse in area contaminated by landfill/dredged sludge. Max Cu = 543 mg/kg measured in carcass (reported as 164 mg/kg wet weight).	Soil (70 - 1510 mg/kg), vegetation tissue (9.8 - 600 mg/kg), invertebrate tissue (species mean values: 67.7 - 462 mg/kg)
Evaluation of some sources of variability in using small mammals as pollution biomonitors	2008	Gonzalez, X. I., Aboal, J. R., Fernandez, J. A., and Carballeira, A.	Chemosphere	Wood mouse, Spanish shrew, and great white-toothed shrew in area contaminated by mining/mine tailings. Max Cu = 35.7 mg/kg measured in organ.	None
Ecotoxicology of Copper and Cadmium in a Contaminated Grassland Ecosystem. III. Small Mammals	1987	Hunter, B. A., Johnson, M. S., and Thompson, D. J.	Journal of Applied Ecology	Field vole, wood mouse, and common shrew in area contaminated by smelting. Max Cu = 258 ± 12.5 mg/kg measured in intake (diet contents).	None
Ecotoxicology of Copper and Cadmium in a Contaminated Grassland Ecosystem. IV. Tissue Distribution and Age Accumulation in Small Mammals	1989	Hunter, B. A., Johnson, M. S., and Thompson, D. J.	Journal of Applied Ecology	Field vole, wood mouse, and common shrew in area contaminated by smelting. Max Cu = 152.5 mg/kg measured in organ.	None
Copper, Zinc, and Cadmium Concentrations in Peromyscus maniculatus Sampled Near an Abandoned Copper Mine	1996	Laurinolli, M., and Bendell-Young, L. I.	Archives of Environmental Contamination and Toxicology	Deer mouse in area contaminated by mining/mine tailings. Max Cu = 413.7 ± 362 mg/kg measured in diet contents.	Soil
Evidence of population genetic effects in *Peromyscus melanophrys* chronically exposed to mine tailings in Morelos, Mexico	2013	Mussali-Galante, P., Tovar-Sanchez, E., Valverde, M., Valencia-Cuevas, L., and Rojas, E.	Environmental Science and Pollution Research	Plateau mouse in area contaminated by mining/mine tailings. Max Cu was 19.1 ± 5.8 mg/kg measured in organ.	None
Food chain analysis of exposures and risks to wildlife at a metals-contaminated wetland	1996	Pascoe, G. A., Blanchet, R. J., and Linder, G.	Archives of Environmental Contamination and Toxicology	Deer mouse, meadow vole, and masked shrew in area with contaminated sediment. Max Cu = 10.3 mg/kg measured in carcass (reported as 3.1 ± 0.61 mg/kg wet weight).	Soil (mean: 584.7 ± 279.9 mg/kg), sediment (mean: 464.7 ± 212.8 mg/kg), surface water (5 - 500 µg/L), vegetation tissue (species mean values: 2.2 ± 4.1 - 274.3 ± 320.6 mg/kg), invertebrate tissue (species mean values: 60.5 ± 28.3 - 77.2 ± 30.6 mg/kg)
Small mammal heavy metal concentrations from mined and control sites	1982	Smith, G. J., and Rongstad, O. J.	Environmental Pollution	Deer mouse, meadow vole, meadow jumping mouse, northern short-tailed shrew, and masked shrew in area contaminated by mining/mine tailings. Max Cu = 52.0 mg/kg measured in carcass (reported as 15.7 ± 7.6 µg/g wet weight).	None
Final - Summer 2001 Area-Wide Investigation Data Summary Southeast Idaho Phosphate Resource Area Selenium Project	2001	Montgomery Watson Harza (MWH)	Idaho Mining Association Selenium Committee publication	Deer mouse, least chipmunk, Western harvest mouse, and Uinta ground squirrel in phosphate mining area. Max Cu = 36 mg/kg measured in carcass (reported as 11 mg/kg wet weight).	Soil (6.2 - 130 mg/kg), vegetation tissue (3 - 9.9 mg/kg), invertebrate tissue (0.91 - 46 mg/kg)
Trophic Levels of Small Mammals: Multi-Elemental Composition and Toxic Load	2013	Bezel, V. S., and Mukhacheva, S. V.	Biology Bulletin	Bank vole and Laxmann's shrew in area contaminated by smelting. Max Cu = 131.9 mg/kg measured in diet contents.	None
Food Chain Relationships of Copper and Cadmium in Herbivorous and Insectivorous Small Mammals	1982	Hunter, B. A., Johnson, M. S., and Thompson, D. J.	Metals in Animals, Institute of Terrestrial Ecology, Natural Environment Research Council	Field vole and common shrew in area contaminated by smelting. No mammal tissue concentrations reported, only other ecological factors (vegetation, insects, soil).	Soil (mean: 11025.0 ± 1592.0 mg/kg), vegetation tissue (species mean values: 73.3 ± 12.4 - 138.9 ± 21.7 mg/kg), invertebrate tissue (species mean values: 466.0 ± 108.0 - 952.0 ± 148.0 mg/kg)
Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment	1998	Bureau of Reclamation, US Fish and Wildlife Service, USGS, and Bureau of Indian Affairs	National Irrigation Water Quality Program Information Report No. 3	Wood mouse, field vole, and shrew in area contaminated by smelting. Max Cu = 56.1 µg/g (dry) measured in organ.	Soil (2480 mg/kg)
Bioavailability of Metals and Arsenic to Small Mammals at a Mining Waste-Contaminated Wetland	1994	Pascoe, G. A., Blanchet, R. J., and Linder, G.	Archives of Environmental Contamination and Toxicology	Deer mouse and meadow vole in area with contaminated sediment. Max Cu = 18.9 mg/kg measured in organ (reported as 5.7 ± 0.5 µg/g wet weight).	Soil (mean: 532.2 ± 69.4 µg/g), water (mean: 78 µg/L), vegetation tissue (species mean range: 7.2 ± 1.9 - 274.3 ± 160.3 µg/g)
Bank voles as Monitors of Environmental Contamination by Heavy Metals. A Remote Wilderness Area in Poland Imperilled	1990	Sawicka-Kapusta, K., Swiergosz, R., and Zakrzewska, M.	Environmental Pollution	Bank vole in area contaminated by metallurgical/industrial activity. Max Cu = 51.0 ± 6.1 mg/kg measured in organ.	None

TABLE 4 (continued)
Publications Reviewed and Reported Copper Concentrations in Mammal Tissue and Other Media

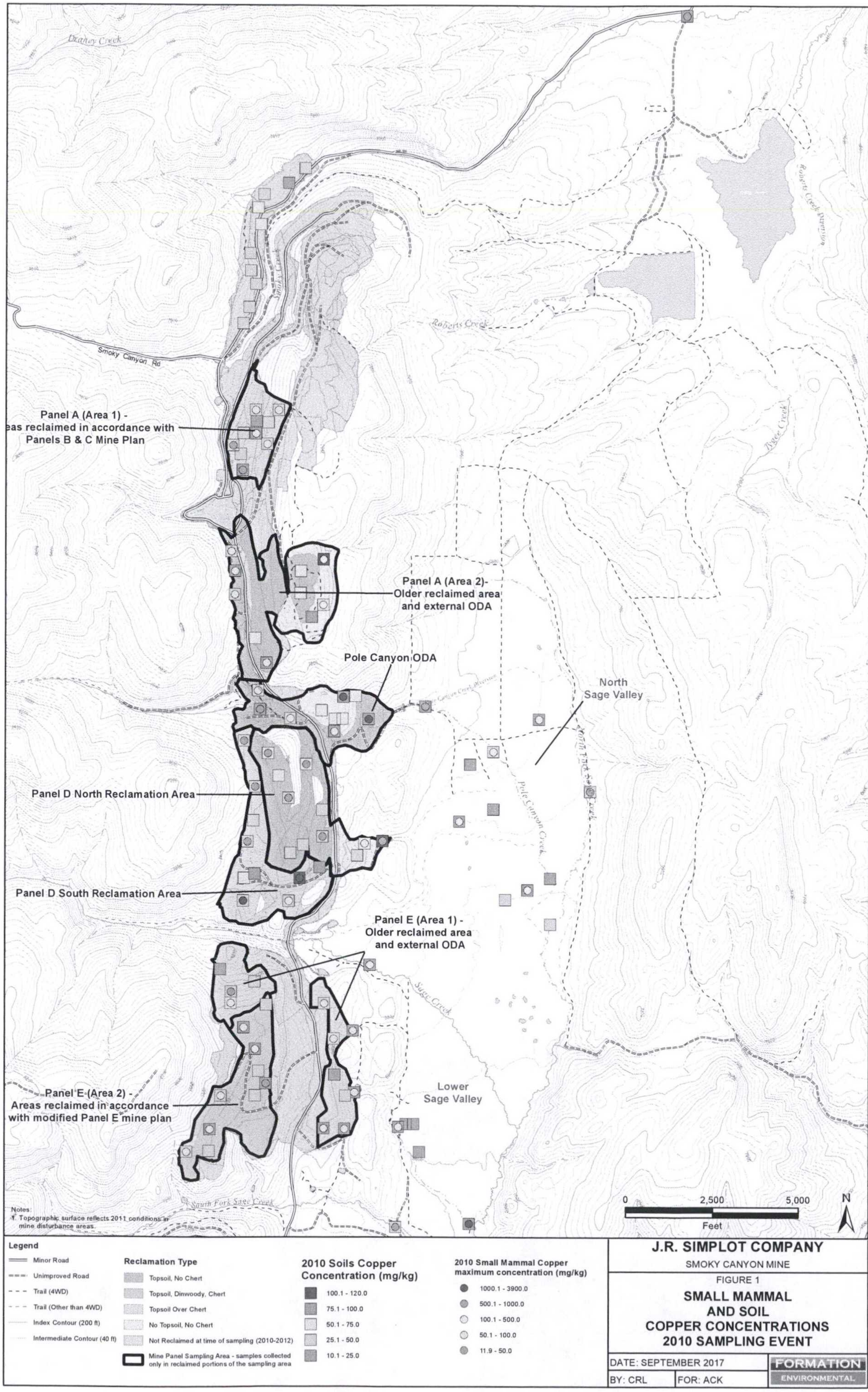
Title	Year	Authors	Journal	Description of Copper Concentrations in Mammal Tissue (dry weight basis)	Copper Concentrations in Other Media
The effect of heavy metals on populations of small mammals from woodlands in Avon (England); with particular emphasis on metal concentrations in *Sorex araneus* L. and *Sorex minutus* L.	1993	Read, H. J., and Martin, M. H.	Chemosphere	Common shrew and Eurasian pygmy shrew in area contaminated by smelting. Max Cu = 32.5 ± 5.65 mg/kg measured in organ.	Vegetation tissue (mean: 151 ± 9.5 µg/g)
Trace elements in Soil and Biota in Confined Disposal Facilities for Dredged Material	1990	Beyer, W. N., and Miller, G.	Environmental Pollution	House mouse, short-tailed shrew, white-footed mouse, and meadow vile in area with contaminated sediment. Max Cu = 20 mg/kg measured in carcass.	Soil (15 - 249 ppm), vegetation tissue (2.5 - 47 ppm), invertebrate tissue (14 - 850 ppm)
Metal Concentrations in Tissues of Meadow Voles from Sewage Sludge-Treated Fields	1982	Anderson, T. J., Barrett, G. W., Clark, C. S., Elia, V. J., and Majeti, V. A.	Journal of Environmental Quality	Meadow vole in area contaminated by sewage sludge. Max Cu = 22.0 mg/kg measured in organ (reported as 6.65 µg/g wet weight).	None
Use of the field vole (*M. agrestis*) for monitoring potentially harmful elements in the environment	1978	Beardsley, A., Vagg, M. J., Beckett, P. H. T., and Sansom, B. F.	Environmental Pollution	Field vole in area contaminated by sewage sludge. Max Cu = 56 mg/kg measured in organ.	Vegetation tissue (mean: 22.7 µg/g)
Metal (Cu, Ni, Fe, Co, Zn, Pb) and Ra-226 Levels in Tissues of Meadow Voles *Microtus pennsylvanicus* Living on Nickel and Uranium Mine Tailings in Ontario, Canada: Site, Sex, Age, and Season Effects with Calculation of Average Skeletal Radiation Dose	1986	Cloutier, N. R., Clulow, F. V., Lim, T. P., and Dave, N. K.	Environmental Pollution	Field vole in area contaminated by mining/mine tailings. Max Cu = 244.4 ± 167.8 mg/kg measured in organ.	None
Mercury, cadmium, zinc, copper, and organochlorine insecticide levels in small mammals trapped in a wheat field	1976	Jefferies, D. J., and French, M. C.	Environmental Pollution	Wood mouse and bank vole in area contaminated by organometallic pesticides. Max Cu = 61.9 mg/kg measured in organ (reported as 18.7 µg/g wet weight).	None
Bioaccumulation of metals and effects of landfill pollution in small mammals. Part I. The greater white-toothed shrew, *Crocidura russula*	2007	Sanchez-Chardi, A., and Nadal, J.	Chemosphere	Greater white-toothed shrew in area contaminated by landfill leaching. Max Cu = 85.90 ± 7.84 mg/kg measured in organ.	Landfill leachates (0.70 - 1.10 mg/kg)
Bioaccumulation of metals and effects of a landfill in small mammals. Part II. The wood mouse, *Apodemus sylvaticus*	2007	Sanchez-Chardi, A., Penaroja-Matutano, C., Ribiero, C. A. O., and Nadal, J.	Chemosphere	Wood mouse in area contaminated by landfill leaching. Max Cu = 39.16 ± 10.36 mg/kg measured in organ.	None
Baseline levels of selected trace elements in Colorado oil shale region animals	1980	Stelter, L. H.	Journal of Wildlife Diseases	Deer mouse in oil shale region. Max Cu = 622 mg/kg measured in organ (liver).	None
Chino Mines Administrative Order on Consent: Site-Wide Ecological Risk Assessment	2005	NewFields	Formation Environmental document	Deer mouse at Chino copper mine in New Mexico. Max Cu = 76 mg/kg measured in liver.	Bird tissue (2.8 - 11.6 mg/kg), snake tissue (1.5 - 39.4 mg/kg), invertebrate tissue (10.5 - 135 mg/kg), soil/sediment (4.2 - 93300 mg/kg), vegetation tissue (4.3 - 261 mg/kg), water (0.0015- 0.14 mg/L)

Notes:

[1] Copper concentrations originally reported on a wet-weight basis were converted to concentration on a dry-weight basis using percent solids information provided in each document, or if percent solids data were not available,

µg/g = micrograms per gram

mg/kg = milligrams per kilogram



J.R. SIMPLOT COMPANY

SMOKY CANYON MINE

FIGURE 1

SMALL MAMMAL AND SOIL COPPER CONCENTRATIONS 2010 SAMPLING EVENT

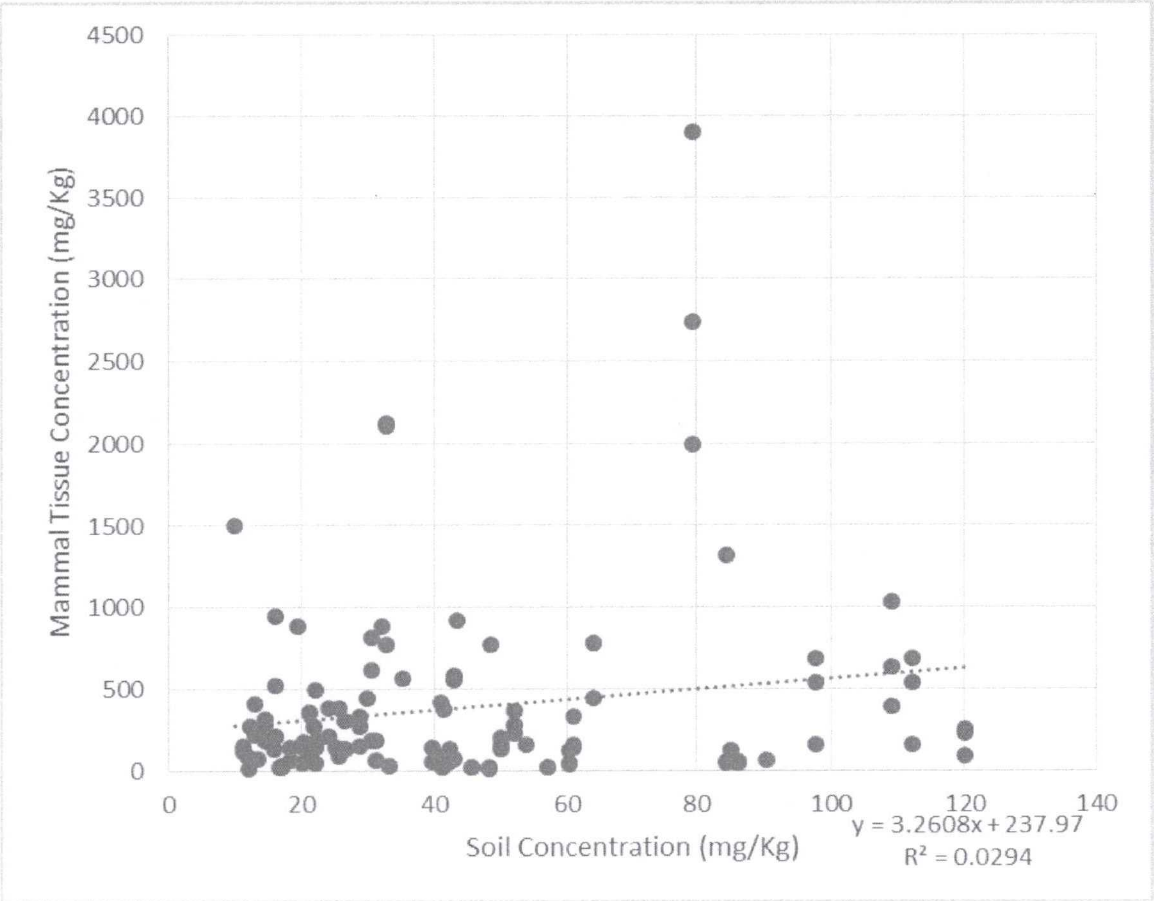
DATE: SEPTEMBER 2017

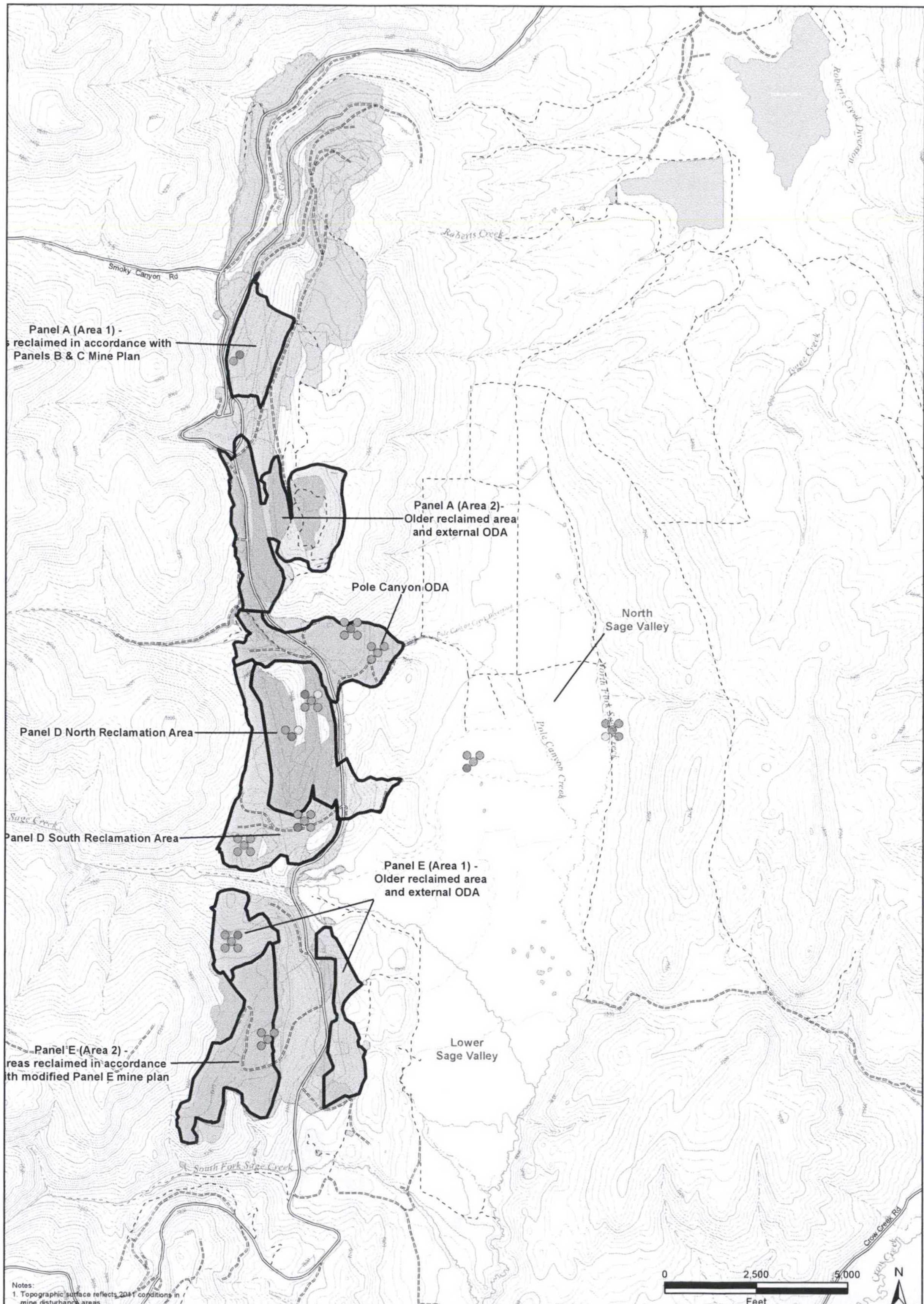
BY: CRL | FOR: ACK

FORMATION ENVIRONMENTAL

FIGURE 2

Relationship between Copper Concentrations in Small Mammals and Soils (2010 data)





Legend

- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Index Contour (200 ft)
- Intermediate Contour (40 ft)

Reclamation Type

- Topsoil, No Chert
- Topsoil, Dinwoody, Chert
- Topsoil Over Chert
- No Topsoil, No Chert
- Not Reclaimed at time of sampling (2010-2012)
- Mine Panel Sampling Area - samples collected only in reclaimed portions of the sampling area

2016 Small Mammal Copper Concentration (mg/kg)

- 1000.1 - 10000.0
- 500.1 - 1000.0
- 100.1 - 500.0
- 50.1 - 100.0
- 10.7 - 50.0

J.R. SIMPLOT COMPANY

SMOKY CANYON MINE

FIGURE 3

SMALL MAMMAL COPPER CONCENTRATIONS 2016 SAMPLING EVENT

DATE: SEPTEMBER 2017

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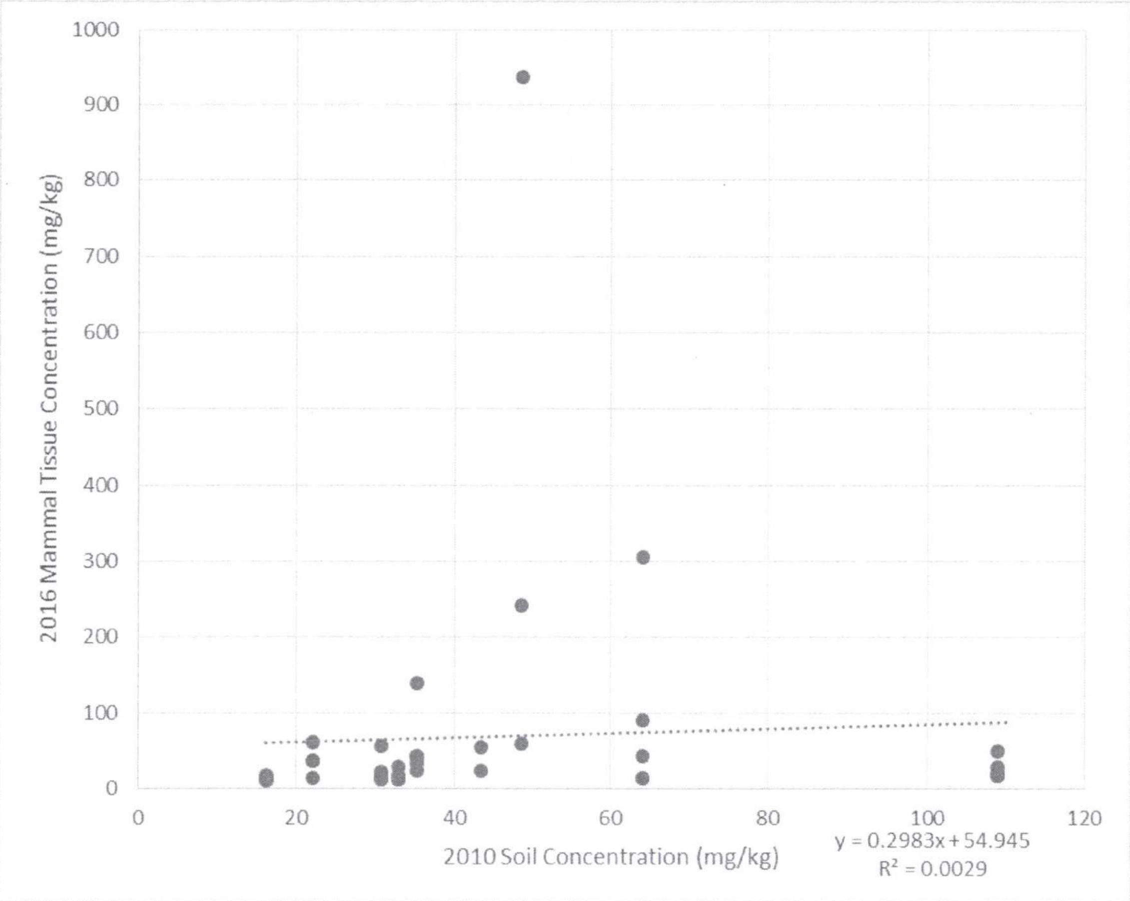
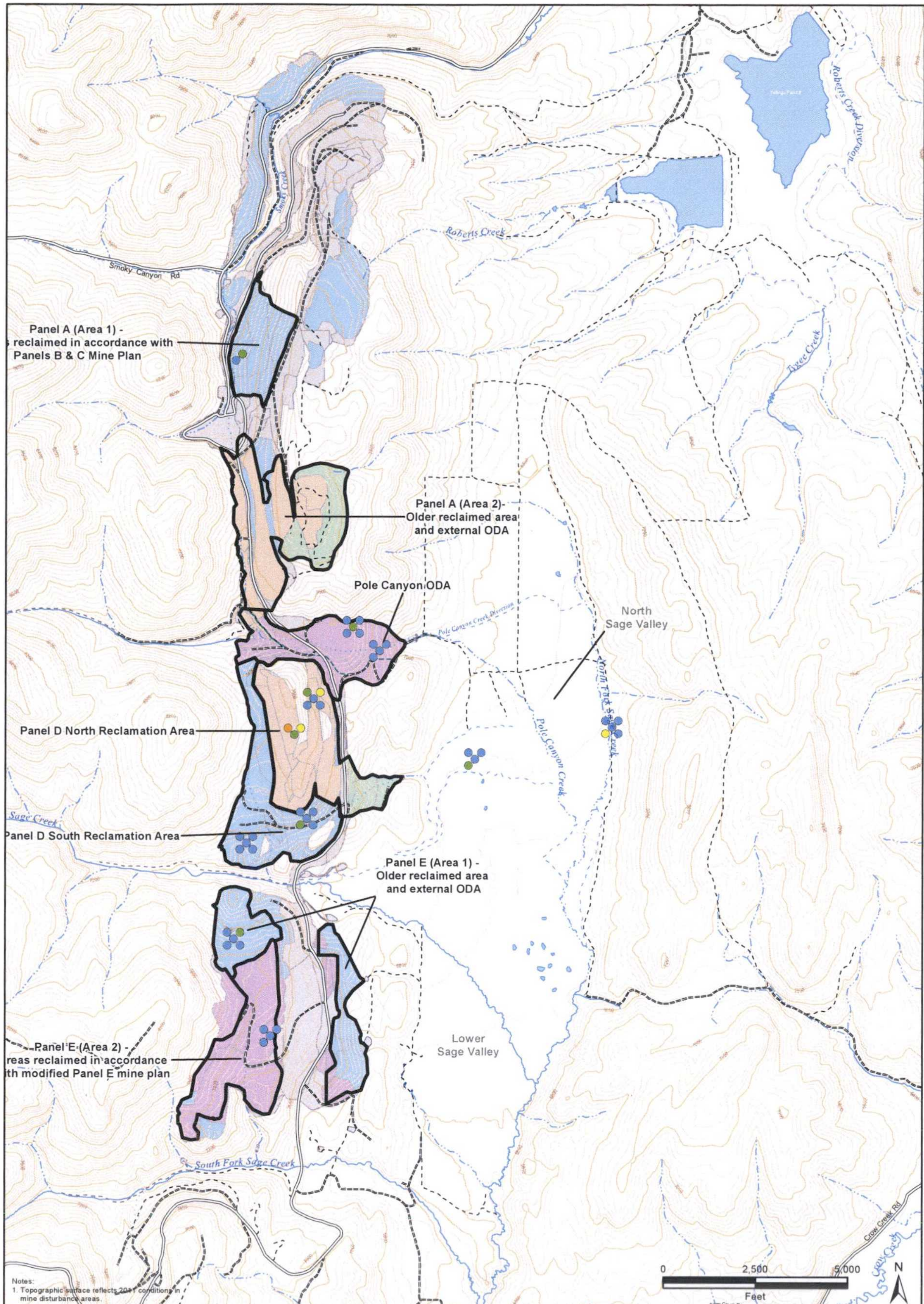
FORMATION ENVIRONMENTAL

FIGURE 4

Relationship between Copper Concentrations in Small Mammals (2016 data) and Soils (2010 data)





Legend

- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Index Contour (200 ft)
- Intermediate Contour (40 ft)

Reclamation Type

- Topsoil, No Chert
- Topsoil, Dinwoody, Chert
- Topsoil Over Chert
- No Topsoil, No Chert
- Not Reclaimed at time of sampling (2010-2012)
- Mine Panel Sampling Area - samples collected only in reclaimed portions of the sampling area

2016 Small Mammal Copper Concentration (mg/kg)

- 1000.1 - 10000.0
- 500.1 - 1000.0
- 100.1 - 500.0
- 50.1 - 100.0
- 10.7 - 50.0

J.R. SIMPLOT COMPANY

SMOKY CANYON MINE

FIGURE 3

SMALL MAMMAL COPPER CONCENTRATIONS 2016 SAMPLING EVENT

DATE: SEPTEMBER 2017

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FORMATION ENVIRONMENTAL

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FIGURE 4

Relationship between Copper Concentrations in Small Mammals (2016 data) and Soils (2010 data)

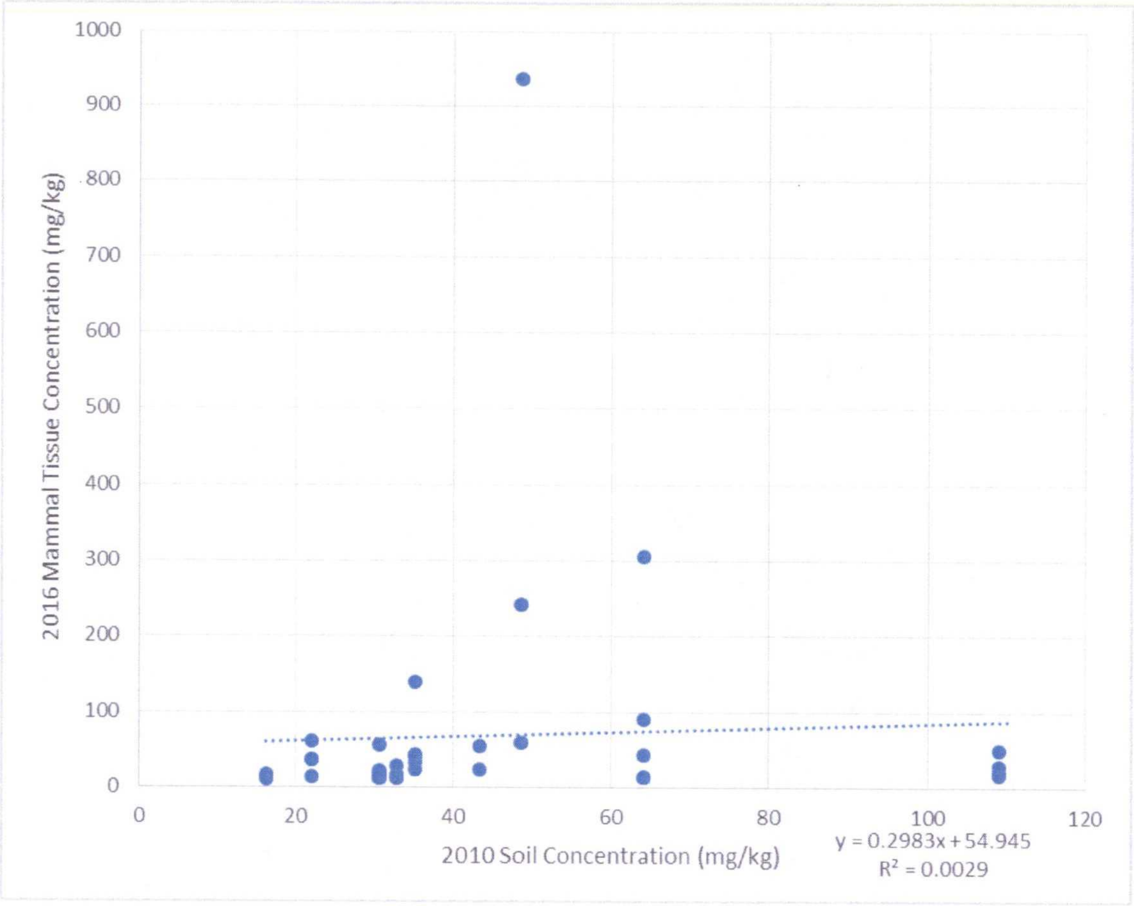

FIGURE 5

Relationship between Copper Concentrations in Small Mammals (2016 data) by ALS and ACZ labs

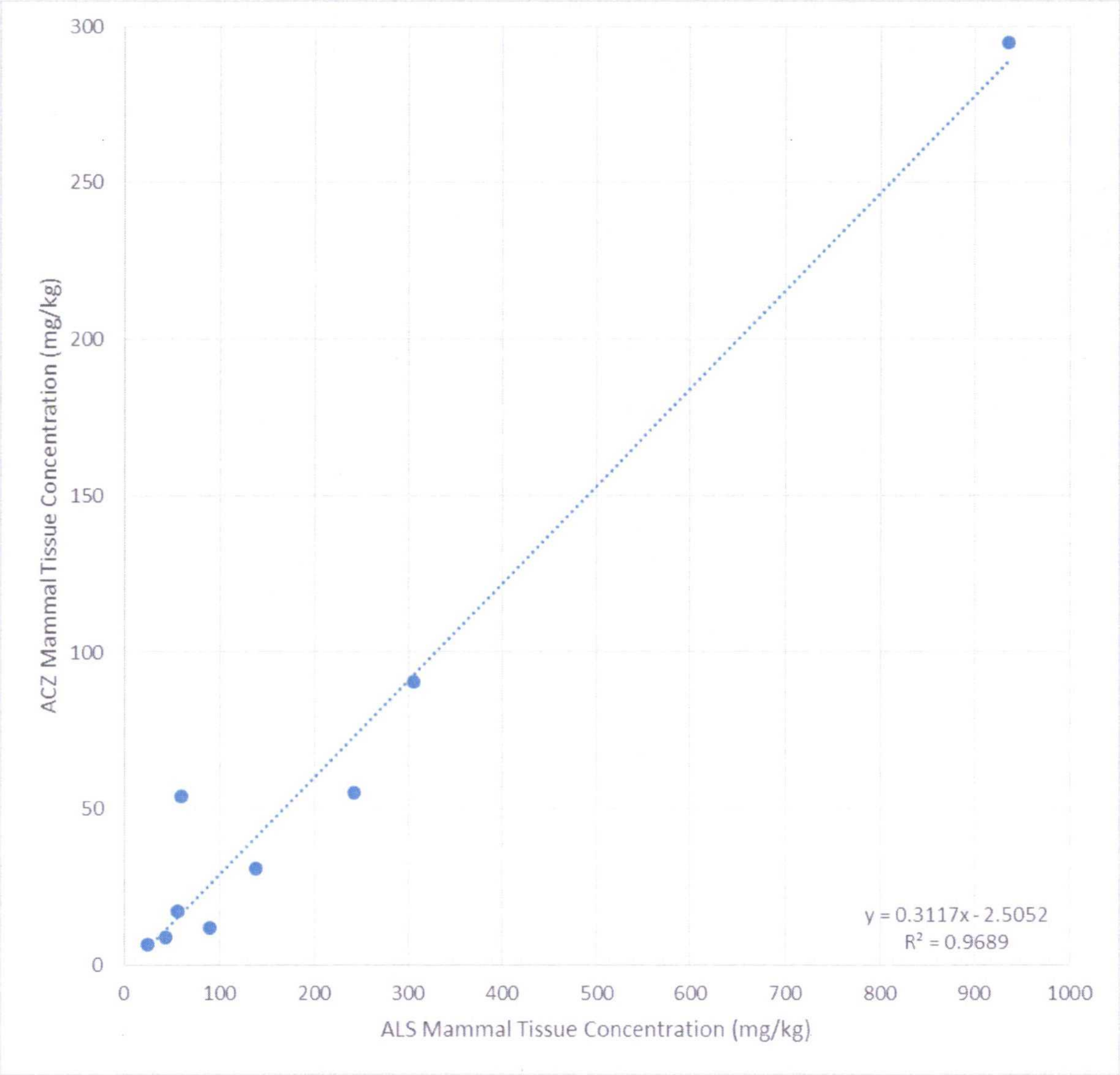

FIGURE 6

Copper Concentrations in Small Mammal Samples Collected in 2010 and 2016